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LOBLOLLY PINE SEED TREES: SELECTION, FRUITFULNESS, AND MORTALITY

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LOBLOLLY PINE SEED TREES: SELECTION, FRUITFULNESS, AND MORTALITY[1]

by

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Successive generations of trees are reproduced from seeds or by vegetative means, such as, shoots, suckers, layering or rooting of detached parts. Reproduction of most hardwood species is doubly assured, for young trees can replace a severed stem with sprout growth, while mature trees often bear many seeds. By contrast, perpetuation of conifer species, at least in pure stands, has been less certain, since sprouting occurs infrequently and seed production may be erratic. For example, loblolly pine produces good seed crops at intervals of 1 to 5 years. If loblolly pine is the species to be grown, many seeds are needed, because it is not unusual for less than 10 seedlings to develop from 1,000 seeds. Germination failures, losses from bird or rodent activity, and unfavorable environmental factors account for the low ratio of seedlings to seeds. If the occurrence of pine seedlings is delayed, it is possible for hardwood sprouts to become established to the extent that, regardless of the quantities of seed provided, pine seedlings in numbers sufficient to produce an acceptable stand cannot survive unless expensive control treatments are applied to the hardwoods (5, 6, 11). Consequently, forest managers who wish to regenerate loblolly pine stands by natural means must reserve from harvest sufficient trees to provide a large supply of seeds at an early date, or defer cutting until there is a big seed crop.

In the Coastal Plain of Virginia and North Carolina, loblolly pines with a capacity for abundant seed production can be identified easily after their crowns become fully developed. They are the trees bearing a large quantity of cones in a good seed year. But full production, at least for second growth trees, is not attained until the trees have been completely released from competition for several years. How, then, can trees that may become prolific be identified before they are fully developed? How frequently do they bear seed in quantities sufficient to restock cutover land? When are the seeds dispersed? How far are seeds dispersed from standing trees, and in what quantities? What mortality of reserved trees may be expected as a result of exposure to wild fires, high winds, lightning, disease, and insect attacks? What volume increment may accrue to the surviving seed trees?

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[1] Experiments begun from 1929 to 1936 were conceived and installed by C. F. Korstian and the late A. L. MacKinney. Since then important contributions to the work have been made by G. M. Jemison, L. E. Chaiken, I. H. Sims, K. B. Trousdell, J. T. Stewart, Helen B. Burgess and others.

[2] Forester, stationed at the North Coastal Plain Branch (Franklin, Va.,) of the Southeastern Forest Experiment Station.

Answers to the above questions, although related, fall in three different sections of this report. The key indicators of fecundity and their identification in uncut stands are described in the first section. Information regarding frequency of seed production, season of dispersal, and distribution from a mature stand is presented in the second section. And the last section deals with considerations of parent stock, mortality, and growth of the survivors.

SIGNIFICANCE AND IDENTIFICATION OF KEY FACTORS

The key indicators of fecundity are cone-bearing history and tree diameter.3/ This important relationship has been disclosed by intermittent observation of 492 trees in four loblolly pine stands thought to be typical of Coastal Plain conditions. Other characteristics, such as total height, crown development, and the ratio of crown-length to total height have not provided a consistent clue to future yield, although they should be considered in the selection of parent stock.

The observations and measurements leading to the identification of prolific seed trees were made in the following locations:4/

1. Hedgepeth tract, near Franklin, Virginia
2. Heckstall tract, near Windsor, North Carolina
3. Surry tract, near Black Creek, Virginia
4. Patty Harris tract, near Emporia, Virginia

The first observations were made in 1929 near Franklin, Virginia, in a mature stand of forest origin where methods of harvest cutting were

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3/ Measured at a point 4.5 feet above ground.

4/ Plots in tracts 1 and 3 were established in cooperation with Camp Manufacturing Co., Inc., Franklin, Va., in tract 2 with Foreman-Blades Lumber Co., Elizabeth City, N. C., and in tract 4 with the Southern Johns-Manville Products Corporation, Jarrett, Va.

being investigated on six plots, each $2\frac{1}{2}$ acres in size (8). The soil, a poorly drained Portsmouth sandy clay, had a site index of 75 to 77 feet.[5] After logging was completed, four selectively cut plots had an average of 66 well-spaced trees per acre with a diameter range of from 3 to 20 inches. Two seed-tree plots had seven well developed seed trees per acre, from 13 to 18 inches in diameter, plus all the original stand under 12 inches in diameter. Cone production was estimated on the central acre of each seed tree plot and on two of the selectively cut plots.

Cone production of each tree was estimated[6] in 1929, '31, '32, '33, '35, '36, '46, '47, and '48. Some trees were almost devoid of cones in years when most of the others produced excellent crops. In years of generally poor cone production, these same "off-schedule" trees frequently matured many cones. Although all trees did not bear cones in unison, their individual capacities could be estimated at any time because all cones maturing in the current season plus most of the cones that matured in the past two seasons were present in the crown at the same time.

Analysis of production records for any one year did not provide consistent results. But analysis of total production by each tree for two 3-year periods, 1931-1933 and 1946-1948, indicated that a strong relationship existed between diameter and fruitfulness during both periods (each factor significant at the 1 percent level). When cone production from 1931 to 1933 is ignored, the relationship between diameter in 1933 and yield from 1946 to 1948 is not so apparent. For example, during the past three years a vigorous, well-proportioned tree, 22 inches in diameter, produced only 60 cones, while a less impressive specimen, 5 inches smaller in diameter, produced 1,000 cones. No cones were collected from these trees, but other samples indicate that in a good seed year each cone may contain from 60 to 100 viable seeds. So it would be possible under favorable conditions for the smaller tree to reforest an acre of cutover land, while 17 of the larger trees would be required to provide the same quantity of seeds. A more striking example of the importance of avoiding trees that have been unfruitful in the past is presented by the 14 trees so carefully selected in 1929 on the plots cut under the seed tree method. Vigor, form, diameter, total height, crown volume and ratio of crown length to total height were all considered in the selection, but no weight was given to the presence or absence of mature cones. Five of these 14 trees still do not produce cones in sufficient quantity to merit the title of "seed trees," although they have been completely released for 19 years and are now 80 to 100 years old.

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[5] Height attained by dominant and codominant trees in 50 years. The average site index for loblolly pine in this region is 80 feet.

[6] Cones on small, open-crowned trees can be counted quite accurately. But it is difficult to see cones on dense-crowned, mature trees. So crop size is usually estimated by carefully examining a selected portion of the crown with the aid of 6 x 30 power binoculars.

Usually trees having few cones from 1931 to 1933 failed to produce very many cones from 1946 to 1948. Ninety-four percent of the barren trees were 10 inches or less in diameter when first observed. These trees had been in the understory of the uncut stand. Although size of cone crop is usually an indicator of future productivity, predictions based entirely upon past fruitfulness may be inaccurate. A tree that produced 128 cones from 1931 to 1933 only matured 12 cones from 1946 to 1948, and another tree with 28 cones in the first period had 860 cones during the second period. These trees behaved contrary to the general rule.

Marked differences in cone production between overstory and understory trees were not found, because there were trees of the same diameter and fruitfulness in both codominant and intermediate crown classes. However, all trees 11 inches and larger in diameter had at least one cone in one or both periods. The correlation between size of present crop and diameter and past cone production for trees smaller than 11 inches in diameter differed significantly from the same correlation for larger trees. Figure 1 shows cone yields for two overstory diameter classes and increase in production for a 15-year period that began two years after complete release by a partial harvest cut. The relationship for trees less than 11 inches in diameter is not shown, as these trees did not produce enough seeds to be an important factor in stand regeneration. Overstory trees yielding relatively large crops from 1931 to 1933, usually doubled or trebled their production during the next 15 years. A more remarkable response was the 10- to 20-fold increase in production by trees having only a few cones during the first period.

Why should there be such a marked difference in response to release?

It appears that this variation may be traced to light and growing space conditions in the stand prior to logging in 1929. Trees with large crops during the years immediately following release had crowns that were usually about 4 feet wider than crowns of small-yielding trees of the same diameter at breast height. Furthermore, a check of crown projection maps prepared prior to logging disclosed that wide-crowned, high-yielding trees usually were free of competition from other overstory trees on two or three sides. Therefore, it appears that the high-yielding trees had a better opportunity to develop their crowns in full sunlight and were mature or nearly so when released. During the first four years after release, narrow-crowned trees noticeably increased their cone production. Thereafter, differences traceable to crown development disappeared.

Unpublished notes by MacKinney regarding observations in 32 uncut loblolly pine stands in the early 1930's indicate that "wide-crowned trees, on the average, produced more cones than narrow-crowned trees of the same diameter. For trees 7 inches and larger, the average number of cones per

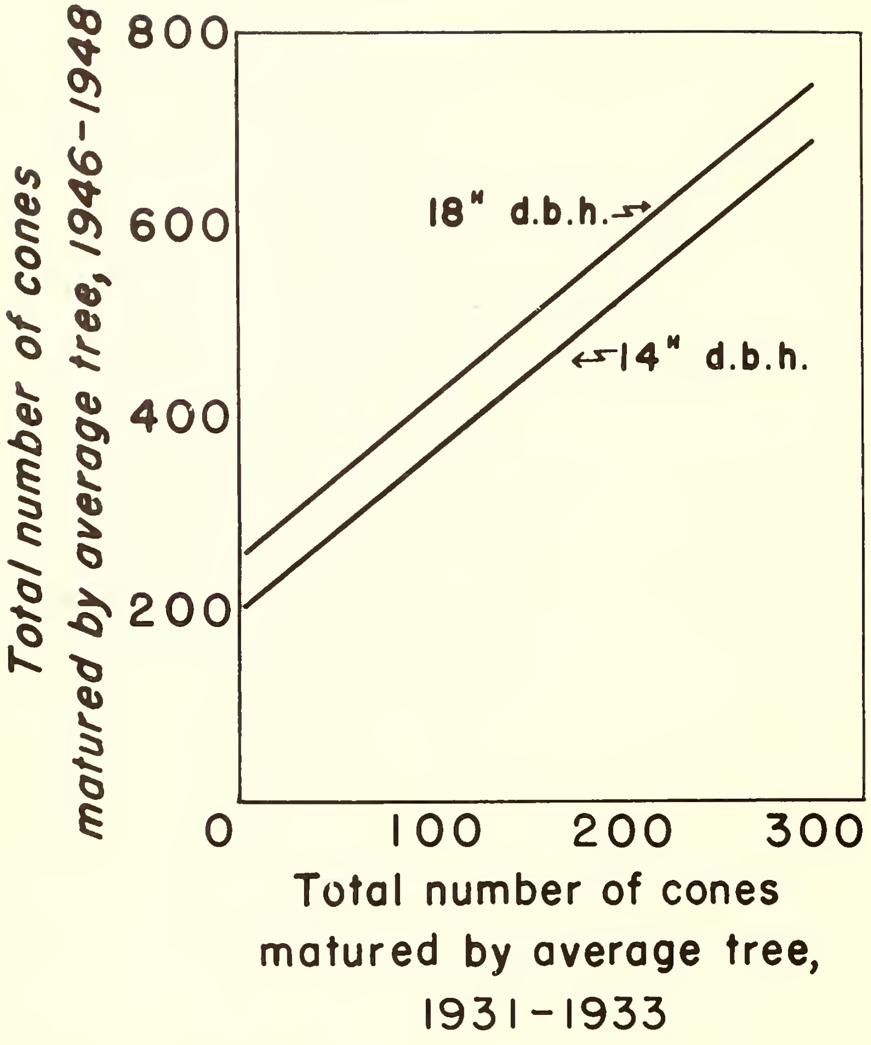

Figure 1.--Increase in cone production by 14- and 18-inch trees of average fruitfulness. This rate of increase was constant for all trees over 11 inches in diameter. The relationship for trees under 11 inches in diameter is not shown.

tree was more closely related to diameter than to any other factor investigated." There is no indication that he tried to correlate current cone yield with past cone-bearing history.

Tract 2

Another check of the correlation between future yield, present diameter and cone-bearing history was made in a well-stocked, 60-year oldfield stand, near Windsor, North Carolina. This tract, containing four plots, each $2\frac{1}{2}$ acres in size, was selectively cut in 1930. The trees were growing on a Coxville silt loam of site index 85 to 88 feet. An analysis of cone production of all overstory trees from 8 to 17 inches in diameter disclosed that yield in 1936 was very closely related to diameter and cone crop in 1933. No cone estimates have been made in this tract since 1936.

Tracts 3 and 4

A check of the correlation between diameter, past fruitfulness and future cone production, as disclosed by observations in the Franklin and Windsor plots, has been made in two young oldfield stands growing on Norfolk sandy loam of average site index. One hundred seed trees were selected in each stand during the 1946-'47 winter season. In addition to determinations of diameter, total height, crown width, and ratio of crown length to total height, each tree was classified according to the number of old cones visible. They were tallied on a scale of 0-25, 26-50, 51-75, and 76-100. The purpose of this classification was to identify trees of like fruitfulness with the expectation that they would produce at the same rate in the future. Examinations in 1947 and 1948 revealed the class limits to be too restricted, as cone production by individual trees varied considerably from year to year. But, in the 45-year-old stand only one tree of the 24 placed in the upper two classes failed to produce more than 50 cones during the 2-year period. In the 35-year-old stand the forecast of trees that would exceed or fall below the 50-cone mark was 90 percent correct.

PERIODICITY, DISPERSAL, AND DISTRIBUTION

Selecting seed trees isn't quite as easy as the discussion to this point implies. There are other factors to be considered, such as frequency of good seed crops, season of seed dispersal, and distribution of seeds from standing trees. If these factors are unfavorable, and logging cannot be deferred until they are favorable, cutting should probably be done by some method that does not require the reservation of seed trees.

Most of the information presented in this section was obtained from a 13-year study at Duke University, Durham, N. C., of seed production by a mature, oldfield loblolly pine stand[7] (10, 13). Some of the Duke findings have been supplemented by additional observations on tracts 1 to 4 and by K. B. Trousdell, of this Station, in the Bigwoods Experimental Forest.[8]

Frequency of seed production

Good loblolly pine seed crops usually occur at intervals of 1 to 5 years (fig. 2). Field examinations indicate that a mature stand will produce enough viable seeds during a good seed year to restock an acre of cutover land with 1,000 or more seedlings per acre, which is considered satisfactory. An adequate seedling stand has not been observed on cutover land following a single fair or poor seed crop. Stand regeneration within one year of logging is a desirable objective. But regeneration within five years is considered satisfactory, in view of the periodic occurrence of good seed crops. (We do not wish to imply that successful stand regeneration is assured with the occurrence of a good seed crop. On many sites, one or more release treatments may be required to free pine seedlings from competing hardwoods.)

An analysis of individual tree records for tract 1 disclosed that the most prolific trees matured cones in each of the 9 years in which they were examined. About 10 percent of the overstory trees behaved in this manner. Many low-yielding trees only had cones in years when the stand as a whole produced a big seed crop. Many other trees failed to develop cones one-third of the time. Some portion of this failure may be attributed to cone destruction by moth larvae and weevils.

Season of seed dispersal

Loblolly pine seeds begin to fall about October 20. As shown in figure 3, peak dissemination is reached by mid-November, and by the end of December seedfall is 84 percent complete (10). In poor years nearly all seeds fall before April, but when there is a good crop a few seeds continue to fall until June.

Distribution of seeds

Some foresters prefer to reserve seed trees in rows, as it is easier to traverse a tract in this manner than it is to select trees randomly over

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[7] A joint study by the Southeastern Forest Experiment Station and Duke Forest staff.

[8] Maintained by Southeastern Forest Experiment Station in cooperation with Camp Manufacturing Company, Inc., Franklin, Virginia.

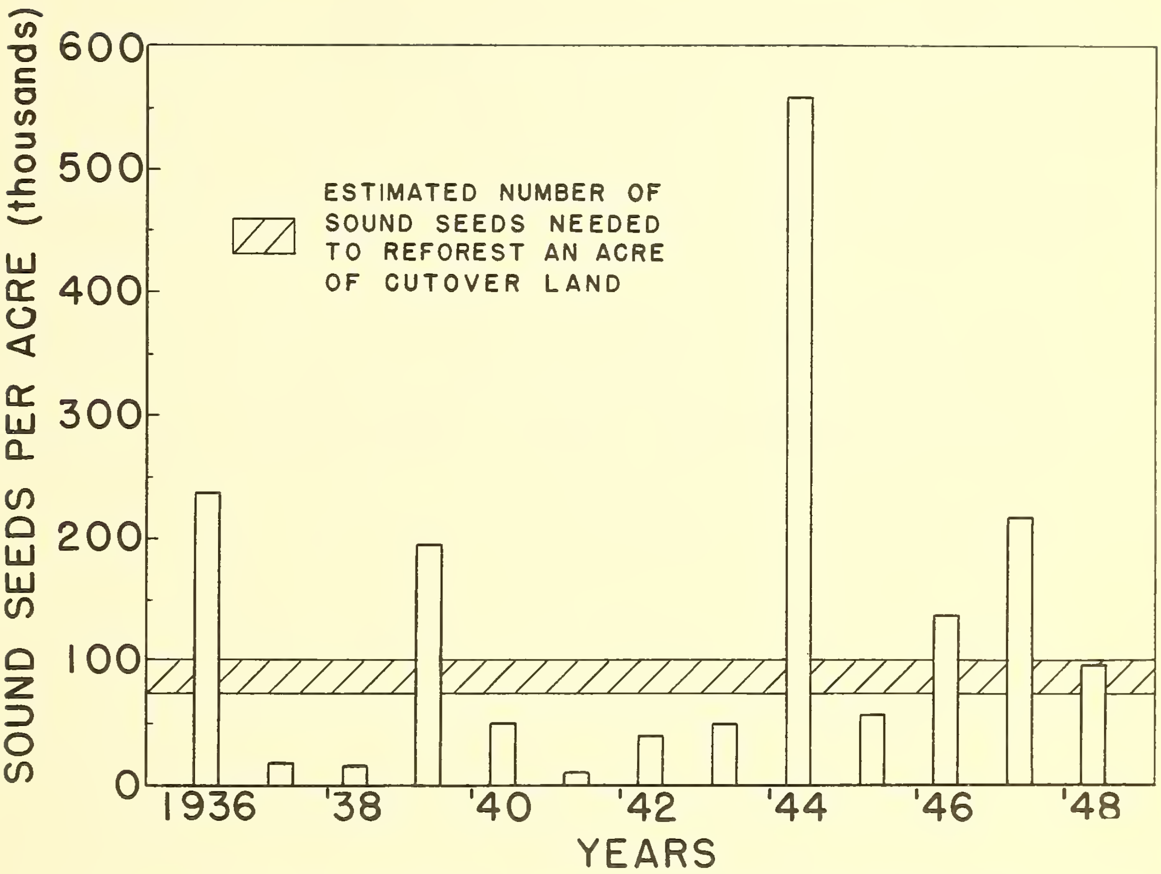

Figure 2.—Seed production by a mature loblolly pine stand, Duke Forest, Duke University, Durham, N. C. Yields from 1936 to 1943 are from a fully stocked stand. Yields from 1944 to 1948 are from another portion of the same stand that had been reduced to one-fifth the original volume by a shelterwood cutting in which only the fastest growing and most fruitful trees were reserved.

the entire area. Other woodland managers cut their stands in strips, leaving alternate strips of uncut forest as a source of seed.

How far apart may the rows be, and what width of strip may be cleared?

Information concerning the optimum spacing of seed trees is lacking, but observations in a cleared strip between two mature stands provide a guide. These observations indicate that cleared strips should not exceed 200 feet in width (fig. 4). The strips should be oriented so that prevailing winds at time of seedfall blow across them. Strip cutting has been used in the harvest of several stands of mature timber in the Bigwoods Experimental Forest (fig. 5). Cleared strips, each 198 feet wide, have been alternated between uncut strips, each 66 feet wide. These tracts were logged in good seed years and each cleared strip is well stocked with pine seedlings (16)

The spacing of seed trees is influenced by the number to be reserved on each acre. The number needed may vary from tract to tract in accordance with stand maturity, site, hardwood development, season of cutting, method of logging, and estimated size of current and prospective seed crops. During a cycle of poor seed production, there is a possibility that seed trees, regardless of the number reserved, may fail to yield enough viable seeds for stand regeneration, since a full stand failed to produce crops of the desired size six times in an 8-year period. Even in good seed years, immature trees usually are incapable of producing large quantities of seeds.

Although definite recommendations applicable to all conditions cannot be made, certain minimum requirements for seed trees have been prescribed. In counties that have endorsed the Pine Seed Tree Act of Virginia, it is required that at least four cone-bearing trees 14 inches or larger in diameter be left on each acre.[9] There is no regulatory act in North Carolina, but many forest owners follow the recommendations of a committee on cutting practices which suggests that at least three trees 14 inches or larger in diameter be left on each acre.[10] Several industrial concerns in both States reserve seed trees at intervals of 50 to 60 feet in rows 100 feet apart, thus leaving 7 - 8 seed trees per acre.

Some woodland managers have devised practices that enable them to secure better results from mediocre seed crops. By scheduling logging for the winter season, i.e., the period between seed maturity and beginning of

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[9] Pine Seed Tree Act, Section 549-al, Code of Virginia.

[10] Cutting practices for the Carolinas, Report of Committee, Appalachian Section, Society of American Foresters, Jour. Forestry 43: 861-870. 1945.

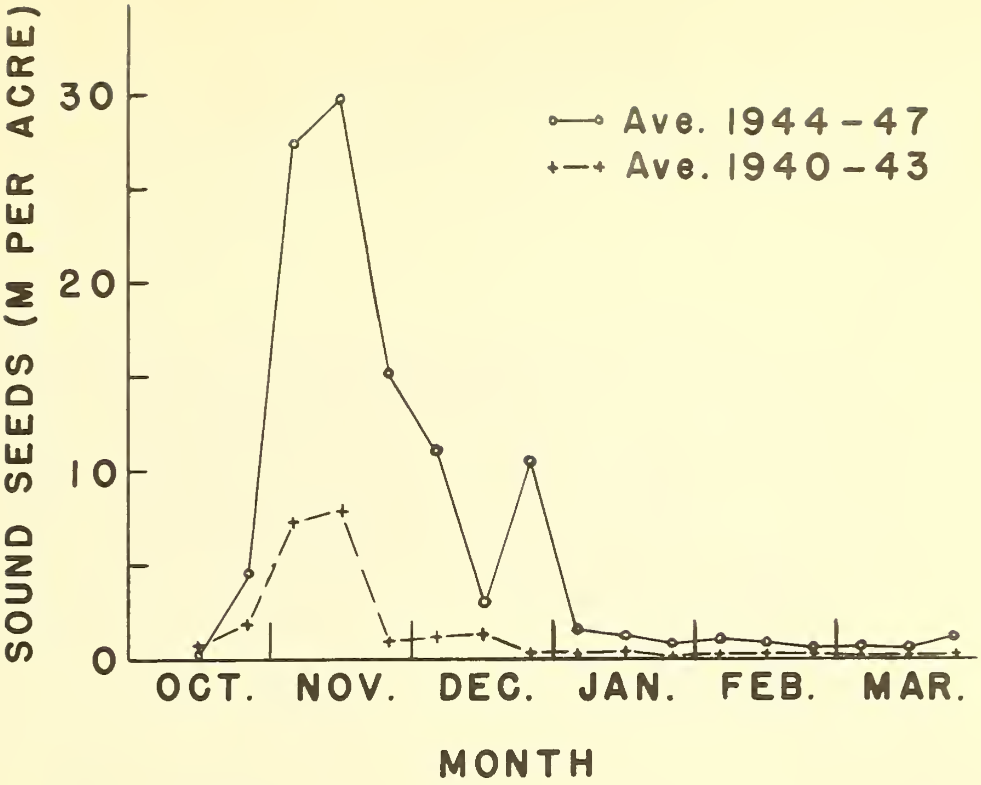

Figure 3.--Seasonal dissemination of loblolly pine seeds during the most productive and least productive four-year periods.

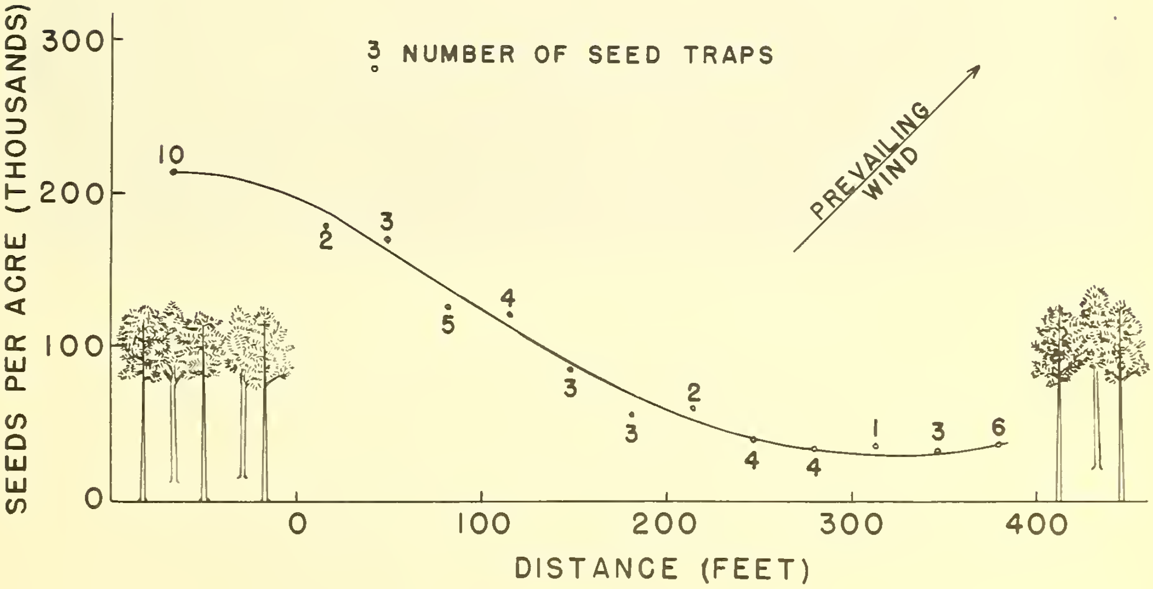

Figure 4.--Average annual dispersal of sound loblolly pine seeds into a cleared strip from adjoining timber. Duke Forest, Durham, North Carolina, 1944-1949.

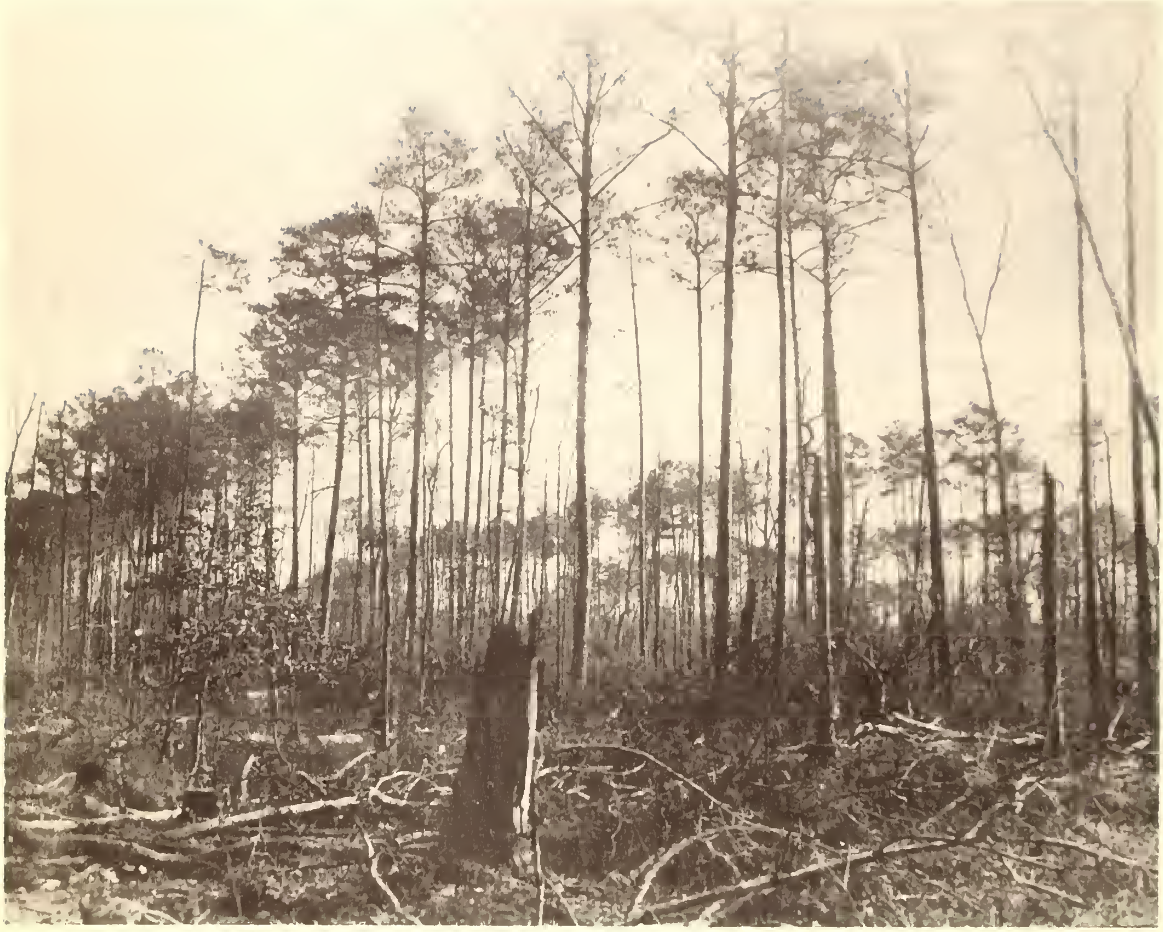

Figure 5.--A seed-tree strip-cutting on a commercial-sized compartment in a loblolly pine forest of coastal Virginia.

germination, all the seeds produced by the entire stand become available for stand regeneration. An example of this method is available on a tract near Franklin, Virginia. An immature, oldfield stand was cut in February and March 1948, leaving 6 - 8 seed trees per acre. Few cones were visible, and examination of 100 reserved trees showed an average of only 90 viable seeds per tree, or less than one percent of the usual requirement for satisfactory stocking (2, 10). However, most of the tract was found to be adequately stocked at the end of the first growing season. It is believed that many of these seedlings germinated from seeds dispersed by the full stand prior to logging.

Another aid in establishing a new stand is the preservation of advance reproduction, in other words, young trees which have become established naturally in a forest before cutting or regeneration operations are begun. K. B. Trousdell has observed that mature stands in the Bigwoods Experimental Forest often contain thousands of one- and two-year-old loblolly pine seedlings. Sometimes enough healthy, well-developed seedlings escape destruction during logging to meet 25 percent of the stocking requirement for a new stand.

If there are few seedlings to save, if little evidence exists that a good seed crop will occur in the next year or two, and if logging cannot be deferred, then better utilization of available seed should be made by seedbed preparation and hardwood control. Seedbed preparation may improve germination and initial survival of seedlings from 100 to 400 percent (16), while hardwood control reduces competition during the critical establishment period (5). The simplest treatment may involve nothing more than a change from "horse logging" to "tractor logging." Seeds resting on mineral soil germinate better than seeds on leaf litter (15), and tractors create more disturbance to the forest floor than wagons or trucks. More elaborate treatments include scarification of the ground before harvest cutting, and prescribed burning either before or following logging (5, 6). Scarification is accomplished with a tractor-drawn heavy-duty bush and bog disk prior to seedfall. Prescribed burning should also precede seedfall. Both treatments improve seedbed conditions and reduce hardwood competition for a limited period.

HEREDITY, MORTALITY, AND INCREMENT

In recent years many industrialists have acted upon the realization that timber is a renewable resource. These men wish to mature successive crops of fast-growing, high-quality trees in a manner that will result in the highest net return per acre. Achievement of this objective involves questions concerning the transmission of growth and disease-resistant characteristics from parent to offspring, probable losses in reserved seed trees, and recovery of volume contained in the survivors.

Heredity has not been studied in any of the stands mentioned in this report. However, as a result of other studies, competent observers have reached definite conclusions regarding the selection of parent stock (1, 3, 7, 9, 12, 14, 17). Mortality and growth of surviving trees have been recorded in tract 1 since 1929, the date when the area was logged, and in tract 2 from 1930 to 1940 (4).

Parent stock

Parent stock is as important in tree breeding as in livestock raising, poultry husbandry, or any other farm activity. Crooked, poorly developed, unthrifty trees should not be selected for seed production even though they may and often do produce large crops of seed. Furthermore, caution should be exercised in the choice of small trees with large cone crops in preference to large trees of lesser productivity. If these trees are of the same age, it is possible that the smaller ones are natural runts and that this undesirable characteristic may be passed on to their progeny.

Loss of seed trees

High mortality of small trees is a common occurrence after a portion of a stand has been harvested. In the 19 years since the Franklin plots were logged, mortality has been as follows:

Dominant trees	2 percent
Codominant trees	5 percent
Intermediate trees	22 percent
Suppressed trees	43 percent

The first death of a dominant tree (class from which seed trees usually are selected) occurred 16 years after logging, and apparently resulted from growth of a canker. Another dominant tree was attacked and killed by insects in the same year. Some of the codominant trees apparently died following injury by lightning. Wild fires, roaring through the tract in 1933 and 1942, may have contributed to losses in the other two crown classes.

Chaiken (4) reported that mortality in the Windsor plots for the first 10 years following logging ranged from 80 percent for 6-inch trees to less than 10 percent for trees 16 inches in diameter. He attributed the majority of deaths to a number of factors operating jointly: mortality due to competition, possible fire damage, wind damage, unusual climatic conditions (moisture deficiency), beetle attacks, and mechanical injury during logging.

In both the Franklin and Windsor plots the greatest mortality occurred in trees with short, narrow crowns.

Recovery of volume in seed trees

Some landowners consider reservation of seed trees to be a loss in revenue, and consequently tend to leave defective trees of low value. However, a profit can be realized if well-formed, fast-growing trees are left in sufficient numbers to provide a commercial cut after a new stand is established. Net growth of the surviving trees on the Franklin plots far exceeds loss from mortality. In 1929, the average dominant tree was 13.8 inches in diameter and contained 153 board feet. Seventeen years later the average diameter was found to be 17.8 inches and volume had become 307 board feet--an increase of 100 percent.

If harvested at the end of the 17-year period, four such trees per acre should return all the volume reserved from the harvest cut plus sufficient growth to yield 68 cents per acre per year if the stumpage is sold for $20.00 per thousand board feet. This 68 cents per acre should defray all annual charges for protection, administration, taxes, and interest while a new stand is being established.

SUMMARY

Results of several studies dealing with selection, fruitfulness, growth, and mortality of loblolly pine trees have been presented in three steps:

1. In the first section evidence is presented to show that prolific trees can be selected by observing the following guides:

    a. Look for trees with a record of high seed production as indicated by the presence of at least 50 old or 50 ripe cones in the crown.

    b. If the past two or three years have been poor seed years, reserve the largest trees among those having some cones, because prolific trees bear a few cones every year. Trees 11 inches d.b.h. or smaller cannot be depended on as good seed trees.

2. The second section gives the following information regarding frequency of seed production, season of dispersal, and distribution:

    a. One average and five good seed crops occurred in a 13-year period. The longest period between good crops was four years.

    b. One good seed crop will contain enough sound seeds to provide an adequate number of seedlings, but, on many sites, special cultural measures may be required before the seedlings become established.

c. Most loblolly pine seeds are dispersed in November and December. Therefore forest managers desiring to make the most efficient use of available seeds should schedule seedbed preparation and hardwood control before November. Winter logging of critical areas may result in a good seedling stand because all the seeds produced by the stand prior to cutting are available.

d. Some loblolly pine seeds may be carried in the direction of prevailing winds for more than 300 feet but 200-foot cleared strips are recommended as maximum. In the Bigwoods Experimental Forest, satisfactory seedling stands have been secured by alternating cleared 200-foot strips with uncut 66-foot strips. All strips are at right angles to prevailing winds.

e. Spacing requirements for seed trees are not known, but it is apparent that enough trees cannot be reserved during periods of poor seed production. When mediocre seed crops are expected, better seedling stands can be obtained by:

Winter logging so that all seeds will be available.

Protection of seedlings present in the uncut stand.

Seedbed preparation to improve germination, or hardwood control to reduce competition.

3. The third section deals with heredity, mortality, and growth of surviving trees:

a. Healthy, well-developed, fast-growing trees of good form should be selected as parent stock.

b. Highest mortality has been observed in understory trees with short, narrow crowns. Therefore dominant trees with large crowns should be selected for seed production, provided they have been fruitful in the past as indicated by the presence of many old cones.

c. The net volume of seed trees has been known to double within 17 years. This rate of growth, if made by four 14-inch seed trees per acre, will defray carrying charges on cutover land until a new stand becomes established.

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